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TRANSITIONAL EFFECT OF THE POSITIVE EXCESS OF SLOW MESONS

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In the problem concerning the sign of the charge of mesons in cosmic rays one often assumes "positive excess," designated delta, to be about 20 percent. (Ordinarily "positive excess" refers to mesons over 100 Mev; however, 20 percent is sometimes assumed even for slow or "stopped" mesons, which is also called positive excess.) Delta is defined thus: $\delta = 2\frac{n^+ - n^-}{n^+ + n^-}$ where n^+ and n^- are the number of positive and negative mesons.

However, in spite of about 20 different investigations into this problem there still does not exist sufficiently exact and reliable data on the dependence of delta upon height of observation, meson energy, and properties of matter.

This article describes the delayed coincidence method in determining positive excess for slow mesons with 2-microsecond lives in the atmosphere and under dense layers.

Delta was determined by comparison of the total number of mesons disintegrated alternately in graphite (N_C) and aluminum (N_{Al}) absorber d; measurements were then carried out for various filters D under the apparatus.

In the first approximation the number n of stopped mesons per unit time upon a definite layer (with Z less than 10) is: $n = n^+ + n^-$, while for a heavy substance (Z greater than 10) it is: $n = n^+$.

Accurate determination of delta from the data by this method requires the following three factors:

1. A constant "background" connected with meson decay in the walls of counters 2 and 3.

2. Incomplete decay of "stopped" negative mesons in the graphite (for which the following relation holds: $N_c = n^+ + 0.92n^-$) and their incomplete capture in the case of aluminum (more exactly: $N_{Al} = n^+ + 0.21\ n^-$).

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3. Some difference in the probability p of yield of decay electrons for different absorbers (p_C/ p_{Al} = 1.05).

In all, three series of measurements were carried out: (a) without filter D under the apparatus; (b) with filter D = 40 grams per square centimeter of graphite; and (c) with filter D = 140 grams per square centimeter of lead.

The corresponding experimental results and the values of delta obtained from them (taking into account the above-indicated correction) are shown in the following table:

D (gm/cm^2)	N_c (in hr)*	N_{Al} (in hr)*	$\delta = 2\frac{n^+ - n^-}{n^+ + n^-}$
(a) 0	29.2±0.55	19.8±0.5	-0.27±0.09 [sic]
(b) 40	35.2±0.5	26.2±0.45	0.15±0.06
(c) 140	30.9±0.5	22.7±0.45	0.09±0.08

* The reduced values for N_c and N_{Al} refer to the "pure" effect of delayed coincidence; that is, chance coincidences are already deducted.

In analyzing the results one notes first of all that the data in line b of the table completely agrees with the usual data for the delta value of 100 Mev mesons and, particularly with the data of Nereson (see Phys. Rev. 73,565, 1948), who, by the method of delayed coincidences, obtained at sea level delta equal to 0.15 to 0.18.

The clearly negative value of delta deserves special notice, this value holding for D equals 0, that is, for mesons which reach the apparatus immediately from the air with 30-45 Mev energies. The presence of the unusual transitional effect for delta can be fully explained by the assumption that part of the observed mesons are decay products of certain nucleo-active "shorter-lived" mesons of small energy, a type of pi-mesons. (An assumption of a similar chain decay of varitrons was made by A. O. Vaysenberg in Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, 19, 727, 1949 [see FDD Per Abs 61/49T79])

This assumption does not contradict existing data on the transitional effect of pi-mesons of both signs (see Harding and Perkins, Nature 164, 285, 1949). But in this case, secondary mu-mesons created during the decay of short-lived mesons stopped in dense matter will possess only a positive sign, while during decay in the air, that is, in flight, short-lived mesons of both signs must make their contribution, which fact leads to a decrease in delta.

If one notes also the fact that, according to previous investigations (see G. B. Zhdanov and A. A. Naumov, Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki 19, 273, 1949 [see FDD Per Abs 38/49T99]) with this method, the number of slow mesons (up to 150 Mev) of secondary origin in the air is about 25 to 30 percent, then the figures in lines a and b in the table will permit one to carry out corresponding considerations quantitatively. It turns out that during the flight of secondary mesons not exceeding 40 grams per square centimeter, the short-lived mesons must consist of at least 70 percent negative particles (for greater values of flights the evaluation is merely increased).

A similar comparison for D equals 0 and D equals 140 grams per square centimeter of lead (lines a and c in the table) complicates the possible dependence of the generation of short-lived mesons upon Z. However, the absence of any notable increase in delta with increase in thickness of filter D up to 140 grams per square centimeter, instead of 40 grams per square centimeter, apparently permits one to conclude that the flights of short-lived mesons in matter do not exceed 40 grams per square centimeter to any considerable extent.

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On the other hand, these flights must, on the average, considerably exceed the total thickness of the walls (2.5 grams per square centimeter) of the "telescope" which registers the mesons in the apparatus. (The absence, established by A. Abdullayev, G. Zhdanov et al., of a noticeable transitional effect of very slow mesons of both signs from air to graphite confirms that the corresponding energy on the average substantially exceeds 10 Mev.) The above-indicated flights correspond to an average energy of secondary mesons from 20 to 100 Mev.

As for the conclusion concerning the predominant role of negative short-lived mesons, a similar result was observed in a test for slow pi-mesons created in an accelerator (see Burfening et al., Phys. Rev. 75, 382, 1949).

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